A MQTT-based Guide and Notification Service System

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Abstract **In recent years, the concept of Internet of Vehicles (IoV) is becoming a hot research issue. However, too much and clutter information received by drivers through IoV may affect their driving attention. It is necessary to provide drivers effective guide and notification services according to time, locations and events. This study proposes a Message Queue Telemetry Transport (MQTT) based guide and notification service system to provide information to the drivers. We establish a hierarchical and geographic grid architecture which provides location-based services. We also collect information from the vehicles, road and environment to calculate the weight of roads.**

Keywords: IoV; MQTT; Guide; Notification.

I. INTRODUCTION

"Internet of Vehicles" (IoV) is an important development topic in "Internet of Things" (IoT). Through combining a variety of technologies such as advanced sensing technology, communication technology, network technology, data processing technology and information dissemination technology, IoV interacts closely with road users, vehicles, roads and environments. In IoV environments, we need to fuse the sensing data of traffic sensors and environmental sensors in addition to the vehicle interior sensing data, and to send the information to a large number of users after data fusion or event detection. Due to the huge amount of data exchange on IoV, the network will experience a heavy load and it is also very difficult to transmit data to all users at once. Therefore, it is necessary to provide information in accordance with the user's demands and resolve the issues of network scalability.

Message Queue Telemetry Transport (MQTT) [14] is a lightweight protocol introduced by IBM and suitable for using on IoT. It is an application layer protocol in the OSI model based on TCP/IP and its header size is fixed to two bytes for all types of packets. Therefore, it is suitable for devices which have limited processing or over low-bandwidth networks.

In the environment of IoV, if there is too much information sent to drivers, additional burden may occur and affect driving safety. This information might be dispensable when not under specified conditions despite its importance. As a result, we hope to provide an adaptive service to filter out the information that users do not currently need and send information to users according to the individuals, times, places, etc. Location-Based Service (LBS) is a popular demand that many services currently use. It provides a variety of services according to the user's location and geographic information. We will combine the above factors to provide an adaptive service. It is feasible to obtain a variety of guides because of the advancement of technology, and the vast information from mobile devices.

The rest of the paper is organized as follows. Section 2 describes the recent research and technology related to this paper. Section 3 discusses the main method about our proposed guide and notification service schemes. Section 4 shows the prototype of our implementation. Section 5 presents the experimental results. Finally, Section 6 summarizes our conclusions and future work.

II. RELATED WORK

In recent years, IoV is proposed to provide a more convenient service. Yang et al. [10] considered not only the connection of vehicles but also roads, environments and pedestrians in IoV to improve drivers and pedestrians safety. Wei et al. [9] used IoV technology to collect vehicle's and driver's information, and then clarify the accident liability and insurance claims when an accident occurs. Cheng et al. [2] discussed the communication and routing methods that are suitable for using in IoV. After the vehicles, roads and people can stablely exchange information, Alam et al. [1] presented the architecture of social Internet of vehicles to provide an effective method to exchange safety or entertainment information.

In the future, most of the articles and devices will be connected to the Internet. Therefore, the huge number of devices are a challenge for network bandwidth. It is necessary to develop some protocols suitable for using in IoT environments [4]. These protocols enhance the effectiveness of networks with lightweight packets or special information exchange mechanism. MQTT and Constrained Application (CoAP) [12] protocols are popular protocols in IoT and have many discussions. The publish/ subscribe model used on MQTT is very suitable for notification service when an event occurs. Szabó et al. [8] presented an application by publish/ subscribe model to share and collect information in the city.

Due to the increase of information sources, we can collect a large number and various types of information. However, not all of the information is required in the normal time, so it is necessary to provide an adaptive service. Adaptive services provide various types of services according to the location, time and people. Guo et al. [3] presented an information-sharing manner to share activity or business information according to the location of users. In addition, event-driven is also a way to achieve adaptive services. They will sense only when a specific event occurs. Nguyen et al. [6] used an event-driven mechanism to track vehicles. In order to send the information to the drivers and let the drivers understand the information clearly, it is necessary to develop an effective guide and notification manner. Han et al. [5] proposed a parking management platform to share the parking information and guide the drivers to find parking spaces. From the past to the present, there are many studies to solve the problem of finding the best guide path. Schakel et al. [7] guided drivers to avoid traffic jams.

III. GUIDE AND NOTIFICATION SERVICE SCHEMES

In this section, we will establish certain mechanisms to complete our guide and notification service schemes, including location-based and hierarchical grid architecture, data collection mechanism, and origin-destination guide and notification model. As shown in Figure 1, the mobile device in our system will receive the information from control center and the sensor is set to collect the data. We also analyze the historical data to help our system provide more diverse and accurate services. The control center is responsible for data detection and publishing the appropriate guide and notification information to the users.

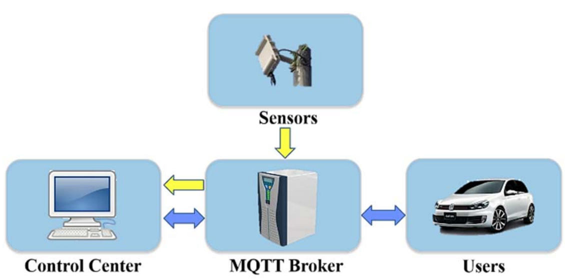

Figure 1 System Overview

In order to provide a location-based service, we have to determine the locations of users and data sources. We can then send the information to the user who arrives to the location and has a pre-defined distance with the source. We will use the geographic grid technology to divide the map into grids, as shown in Figure 2. Thereby, we can define the position of the users and the information sources. The user can obtain the current latitude and longitude via a GPS and calculate the user's grid location by the formula expressed as $Gridof(x_i, y_i) = \left[\left\lfloor\frac{x_i}{d}\right\rfloor, \left\lfloor\frac{y_i}{d}\right\rfloor\right]$, where (x_i, y_i) is the latitude and longitude coordinate of the user and d is the grid size. In addition to determine the user location, all the information collected by roadside sensors, environmental sensors and historical data will also be assigned to the corresponding grid based on their location.

We will then establish a route map based on the map and grid architecture. The grid group on the route map is the data collection range of each road. In the past, the grid had an entity header to collect and concentrate data. With the MQTT and publish/ subscribe model, there is also a MQTT topic to collect data, but the topic is not physically preset. The data will be collected and sent to the cloud data center.

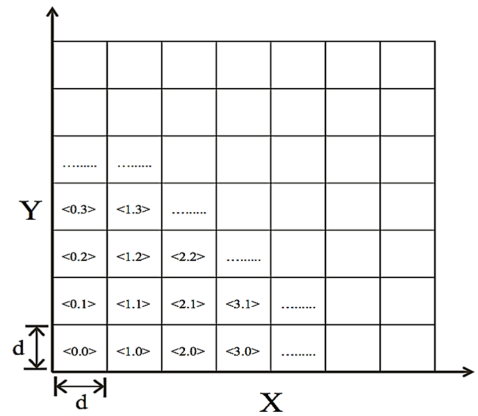

Figure 2 Geographic Grid

The data sources used in this work include vehicle detector (VD), particulate matter (PM), traffic accidents and points of interests. The VD is the main source of the current traffic information, it can be laid on the pavement or structures above the road to get traffic data. In the VD data, longitude and latitude are the location coordinates of the VD device. Because the VD returns data every five minutes, the date time means the data starting time and continued for five-minute data. The vehicle volume is the number of vehicles in five-minute interval. Avg speed is the average speed of all vehicles in five-minute. PM is microscopic solid or liquid matter suspended in the Earth's atmosphere made by humans or nature and it will adversely affect human health.

In order to provide the guide and notification service for drivers, such as the parents who wish child safety to avoid dangerous roads, we collected the accident traffic data from the Taichung City Government Bureau of Transportation. Through analysis of the time and place of the accidents, we can calculate the safety of each road. The points of interest mean the places drivers may have interest in and stay for a particular purpose, for instances, department stores, restaurants, parks, scenic sites and parking lots.

With the data we obtain from multiple sources, we can guide a way that best meets the needs of users. We will use a weight function to calculate how we select the best guide according to multiple conditions. The weight can be expressed as

$$\mathrm{W(t)} = \sum_{i=1}^{n} W_i * Function_i(t) \ \ ,\sum_{\mathrm{i=1}}^{\mathrm{n}} \mathrm{W_i} = 1$$

where there are n conditions that need to be considered and W_i is the weight factors and coefficients for $Function_i(t)$ that also mean the degree of user care about for this conditions. The t is the time zone and time interval of this condition. We group every two hours to a time zone and the time zone numbers is from 1 to 12. Moreover, we also differentiate a week to weekdays and the weekend, because the behavior of drivers, traffic situations and users' needs are different during weekdays and weekends.

In our adaptive guide and notification service, we use four conditions (n=4) to calculate the weight and select the best road. The conditions include time spent (T), safety (S), particulate matter (P) and interest (I). The weight function can be expressed as $\mathrm{W(t)} = W_1 * T(t) + W_2 * S(t) + W_3 * P(t) + W_4 * I(t)$. With a lower total value of cost $\mathrm{W(t)}$, the path is more conform with the user's needs. The data we collected to determine the weights has different types and measurements. In order to avoid the different internal structures impacting on the results, we will normalization the data. With the distance data of the road, we calculate the travel time T(t) from speed information we will spend on this road as

$$\mathrm{T} = \frac{(d/v)}{T_{avg}}$$

where d is the distance of two intersections, v is the average speed of the vehicle on this road. We use the average spend time to normalize the time data. In the accident data, we will count the number of accidents that happened in the specific time zone, road, and intersection to establish safety factor. If there are fewer accidents happening on this road, the safety factor will be better. P(t) is the harmful degree level of PM value. The value of I(t) will be calculated by the amount of points of interest and the point on the open hour in the time zone t. Then, we use the A* algorithm [11] as a basis to calculate a path conform with the user's needs.

IV. SYSTEM IMPLEMENTATION

We will use the MQTT protocol to establish the core architecture in our system. We will install the Mosquitto [13] on an Ubuntu operating system server hosting as the MQTT broker. The control center is set up in a Windows host and designed by C#. We will design the user interface in IOS tablet. In the part of communications, users and broker connect with 3G or LTE and the broker connects to the control center with Ethernet or Wireless network.

The user interface that we designed is shown in Figure 3, including two parts: guide and notification. The guide interface will display the information and recommendation according to the user's needs. The notification interface displays the current location in normal circumstances. However, when events occur, the event information will be displayed in the map and notified to the user by voice. There is a window on the right hand sole of the map to display guide and notification information such as traffic jams or parking information for the user.

Figure 3 A Snapshot of Our Prototype

V. EXPERIMENTAL RESULTS

In this section, we analyze the real data from the vehicle detectors and traffic accident data. Frist, we calculated the vehicle's average speed from Taiwan Blvd. and Wenxin Rd. in an interval of twenty-four hours as shown in Figure 4. Then, the travel time can be calculated and provided to the guide and notification system.

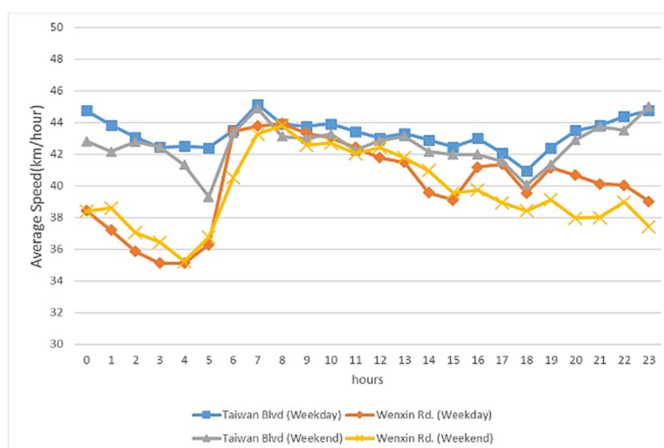

Figure 4 Average Speed of Vehicles

Next, we counted the number of accidents on Taiwan Blvd. and Wenxin Rd. in Taichung City, Taiwan as shown in Figure 5. Therefore, we can choose a road that has least accident probability and avoid the high-risk road.

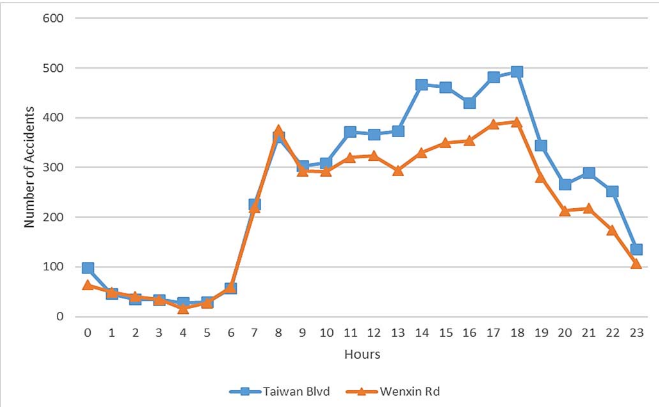

Figure 5 Number of Accidents

VI. CONCLUSIONS

In this paper, we propose an adaptive service system aims to provide guide and notification information to the users. We establish a hierarchical grid architecture to define the position of the users and the information sources in order to provide location based service. Then, we combine the grid architecture and map to establish the route map. We take the advantages of publish/ subscribe, the real time feature of MQTT to collect and send message. We collect the information from the vehicle detector, particulate matter, traffic accident, and points of interest. After calculating the weight for every grid, we can search the best way and provide an adaptive guide and notification services using above hierarchical grid and publish/ subscribe mechanical.

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